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i) Fabrication of New Nb₃Sn Superconductors for High-Field Use

High-field Nb₃Sn superconductors have been fabricated through a new process starting from Nb₆Sn₅ intermediate compound powder. The mixed powder of Nb₆Sn₅ and Nb is encased in a Ta tube, and rolled into tapes without annealing and then heat treated. The Nb₆Sn₅ compound powder can be easily synthesized by the melt diffusion reaction at 900°C between Nb and Sn powders. The effect of different additional elements on the high-field performance of present Nb₃Sn conductors has been studied. A small amount of Ti, Ge or Ta was added to the Nb₆Sn₅ at the time of melt diffusion, while Cu was added to the mixed powder of Nb₆Sn₅ and Nb.

The pure Nb₃Sn tape(NS) fabricated by the present process has a large ρ_n value and a B_{c2} of 24.7T at 4.2K which is considerably higher than that of the bronze-processed Nb₃Sn. The Ti addition yields further increase in ρ_n and B_{c2} . The $J_c(\text{core})$ of the tape with 2at% Ti substitution for Nb(2Ti) is 3.2×10^4 A/cm² at 20T and 4.2K¹⁾. However, the log J_c of NS and 2Ti tapes

decreases linearly with increasing magnetic field as shown in Fig.1. The addition of small amount of Ge or the substitution of small amount of Ta for Nb changes the curvature of log J_c -B curves of specimens at high magnetic fields convex to upward, resulting significant enhancement in high-field performance of Nb₃Sn. The addition of Ge, however, does not increase the ρ_n and B_{c2} values of Nb₃Sn. The Nb₃Sn specimen with 1.0wt%Ge addition and slightly richer Sn concentration shows a $J_c(\text{core})$ of 3.2×10^4 A/cm² at 21T and 4.2K^{2,3)}.

The Ta substitution for Nb increases the B_{c2} of Nb₃Sn like Ti substitution for Nb. In this study, a small amount of Ta substitution for Nb has been found to be most effective to achieve large J_c at high magnetic fields. The optimum amount of Ta substitution for Nb is 5-7at %. The $J_c(\text{core})$ at 22T and 23T at 4.2K of the specimen with 5at%Ta(5Ta) are 3.3×10^4 A/cm² and 2.4×10^4 A/cm², respectively, as shown in Fig.1^{4,5)}. The B_{c2} value of 5Ta specimen exceeds 26T at 4.2K. Even higher B_{c2} may be expected in specimens with 7at% and 10at%Ta substitution. The specimens with Ta substitution are composed of two Nb₃Sn phases with different Ta concentration. A small amount of Cu addition to the specimen decreases the optimum heat treatment temperature from 900-925°C to 850°C. The present new Nb₃Sn superconductor may be quite attractive for high-field fusion devices after the multifilamentary-type conductors become available in future.

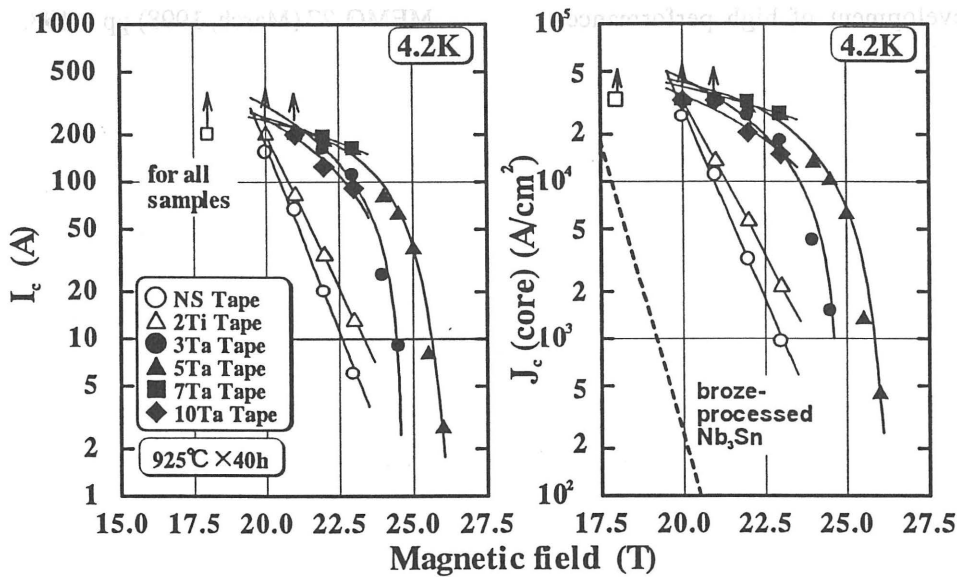


Fig.1 I_c and $J_c(\text{core})$ versus magnetic field curves for Nb₃Sn tapes with different amount of Ta substitution for Nb. Curves for the tapes with 2at% Ti substitution for Nb and bronze-processed Nb₃Sn are also indicated.

ii) Investigation on the Present Status of High- T_c Oxide Superconductors

A series of reports on the present status of the development in Nb_3Sn and other advanced metallic superconductors has been published as NIFS-MEMO-20 (March, 1996) and NIFS-MEMO-22 (March, 1997). The third report of this series covers the recent development of different high- T_c oxide superconductors (HTS)⁶⁾.

Bi-based HTS tapes fabricated by powder-in-tube process are being applied for power transmission cables operating at 77K, superconducting magnets operating at 20K, and high-field insert coils operating at 4.2K. Coated conductors of Y- and Tl-based HTS with improved performance at higher temperatures and fields are being developed. The ac performance and the mechanical tolerance of HTS, which are the key factors in the practical use, are included in this report. The international activities on the standardization of critical current measurement method in HTS tapes has been recently initiated.

The irradiation effects on HTS has gained much interests for enhancing flux pinning in HTS. Meanwhile, the melt processed Y- and RE-based HTS bulk materials are being used as strong permanent magnets. The HTS bulk current leads are much advantageous in saving the consumption of liquid helium in large scale superconducting magnets for accelerator, SMES, fusion devices etc.. The development of high performance

magnetic shielding facilities using thick HTS films is also described in this report.

References

- 1) Tachikawa, K., Tomori, H. and Kuroda, Y., High-field Nb_3Sn Superconductors Prepared through a New Route, *Adv. Cryogenic Engineering*, **42** (1996) pp 1359-1367.
- 2) Tachikawa, K., Kuroda, Y., Tomori, H. and Ueda, M., High-Field Nb_3Sn Superconductors Prepared through a New Route, *Proc. 10th US-Japan Workshop on High-Field Superconducting Materials for Fusion* (Dec. 9-11, 1996, Brookhaven) pp 35-39.
- 3) Tachikawa, K., Kuroda, Y., Tomori, H. and Ueda, M., Improved High-Field Performance in Nb_3Sn Conductor Prepared from Intermediate Compound, *IEEE Trans. Appl. Superconductivity*, **7** (1997) pp 1355-1359.
- 4) Tachikawa, K., Ueda, M., Yamamoto, S. and Yokoyama, T., Effect of Additional Element on the High-Field Performance of Nb_3Sn Superconductors Prepared from Intermediate Compound, *Cryogenic Engineering (Teion Kougaku)*, **33** (1998) pp 315-322 (in Japanese).
- 5) Tachikawa, K., Kuroda, Y., Tomori, H. and Ueda, M., to be published in *Adv. Cryogenic Engineering*, **44** (1998).
- 6) Tachikawa, K. and Mito, T., Reserch Report NIFS-MEMO-27 (March, 1998) pp 1-198.

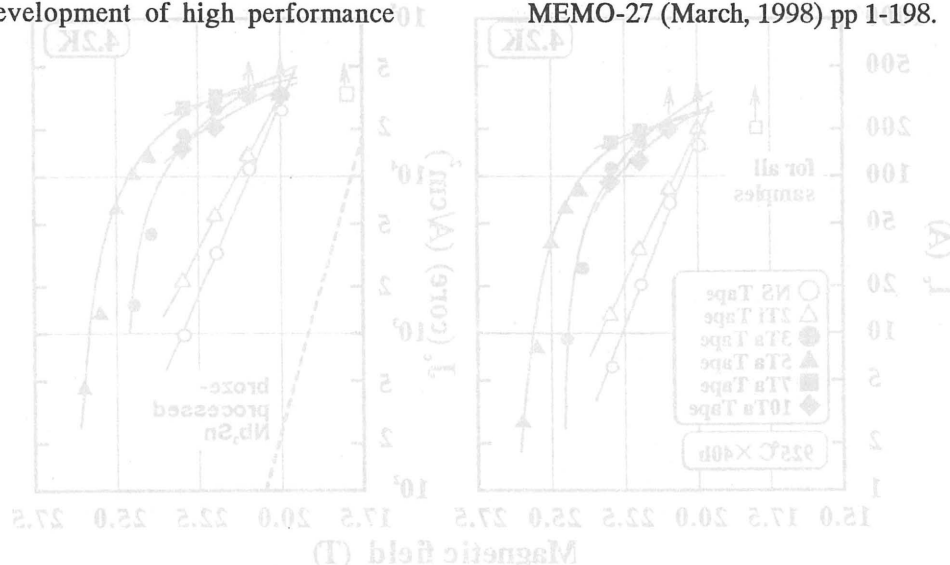


Fig. 1. J_c and $J_c(\text{core})$ versus magnetic field curves for Nb_3Sn tapes with different amount of Ti substitution for Nb. Curves for the tapes with 0.0, 0.2, 0.4, 0.6, 0.8, 1.0 Ti substitution for Nb and bronze-processed Nb_3Sn are also indicated.